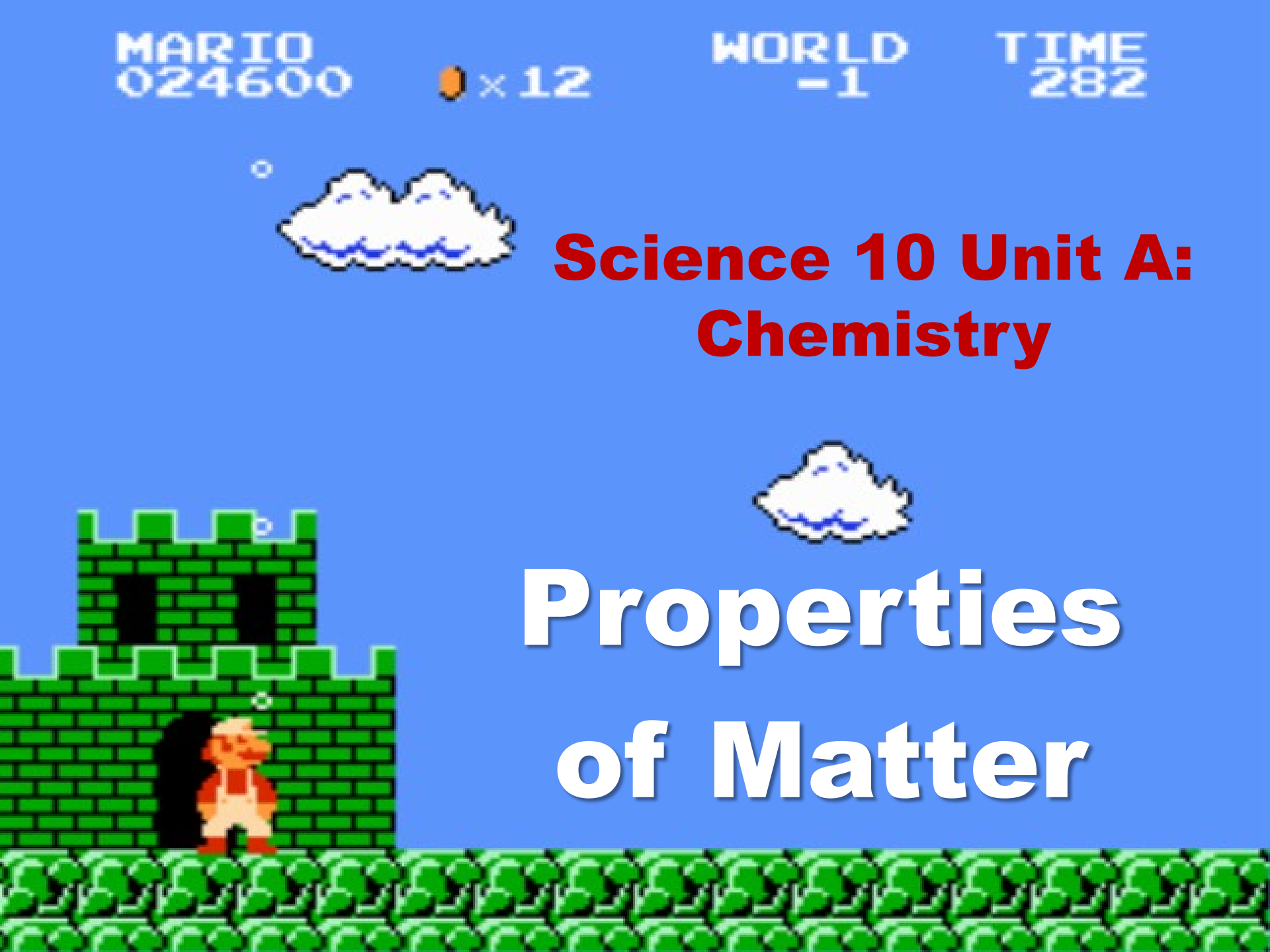


Science 10 Unit A: Chemistry

Properties of Matter

Atomic Models of Matter

how do you define matter?

Matter

- **matter is anything that has mass and takes up space**
- **is composed of atoms**
- **Therefore, to understand matter, we must examine the atom!**

Early Models of the Atom: John Dalton

circa 1803

- **Dalton proposed that the atom was like a billiard ball; a tiny, indivisible sphere.**

Five main points of Dalton's Billiard Ball Model:

1. Elements are made of tiny particles called atoms.
2. All atoms of an element are identical, atoms of different elements are different.
3. Atoms of one element can combine with atoms of other elements to form compounds.
4. Given compounds always has the same relative numbers of types of atoms.
5. Atoms cannot be created, divided into smaller particles, or destroyed in the chemical process.

Successes:

Dalton's Theory explained three phenomenon very well:

1. Law of Conservation of Matter

- **Atoms are not created or destroyed in a chemical reaction, just rearranged.**

2. Law of Definite Composition

- **A compound is composed of the same elements and in the same proportion by mass.**
- **(For example, a water molecule will always be made up of 8.0 grams of oxygen for every 1.0 grams of hydrogen.)**

3. Law of Multiple Proportions

- **Atoms combine in simple whole number ratios to form compounds. Different proportions will yield different compounds.**
- **Eg: CH_4 = methane gas (farts)**
- **C_8H_{16} = liquid octane**

Failures:

- **Atoms are not indivisible.**

Enter: J.J. Thomson

- **Best known for his charge to mass ratio experiment and building the first mass spectrometer**
- **He performed this experiment on whatever was coming out of the cathode ray tubes that were popular at the time**

Cathode ray Tube (CRT)

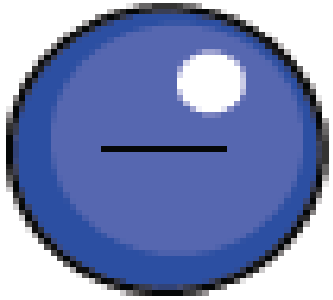
CRT

- **A CRT was produced by placing a battery (voltage) across a cathode (+ive) plate and anode (ive) plate in a vacuum.**
- **This mysterious beam could be deflected by magnets or electric fields.**

Thompson realized that these particles coming out of cathode tubes with a q/m ratio of 1 must be the smallest unit of charge.

He called his new discovery a corpuscle.

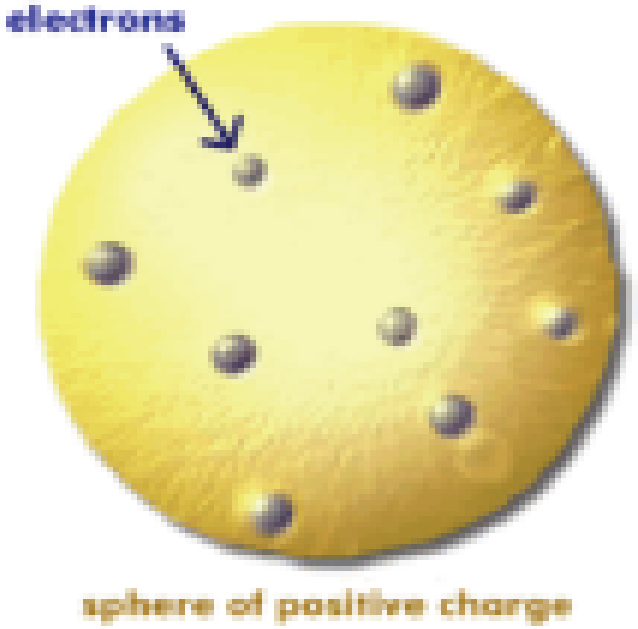
But that name sounded too goofy so everybody started calling them electrons.



Early Models: J. J. Thomson

circa - 1897

- Thomson's model is called the 'raisin bun model'
- it consists of a 'bun' made of positive charge and 'raisins' made of electrons
- the electrons are stuck in the bun and do not move



Successes:

- Thomson discovered the electron and his raisin bun model used the electron to give a more accurate look at the atom.

- Thomson showed that the atom was electric in nature.

- Thomson recognized as the positive part of the atom must be much larger than the negative part.

Failures:

Electrons are not fixed but are free to move.

What about protons?

Enter: Ernest Rutherford

- the "father of nuclear physics"

- held positions at many universities, including as Chair of the Physics department at McGill University in Montreal

- while at the University of Manchester, he performed his famous Gold Foil Experiment.

The Gold Foil Experiment

The experiment was made up a several main components:

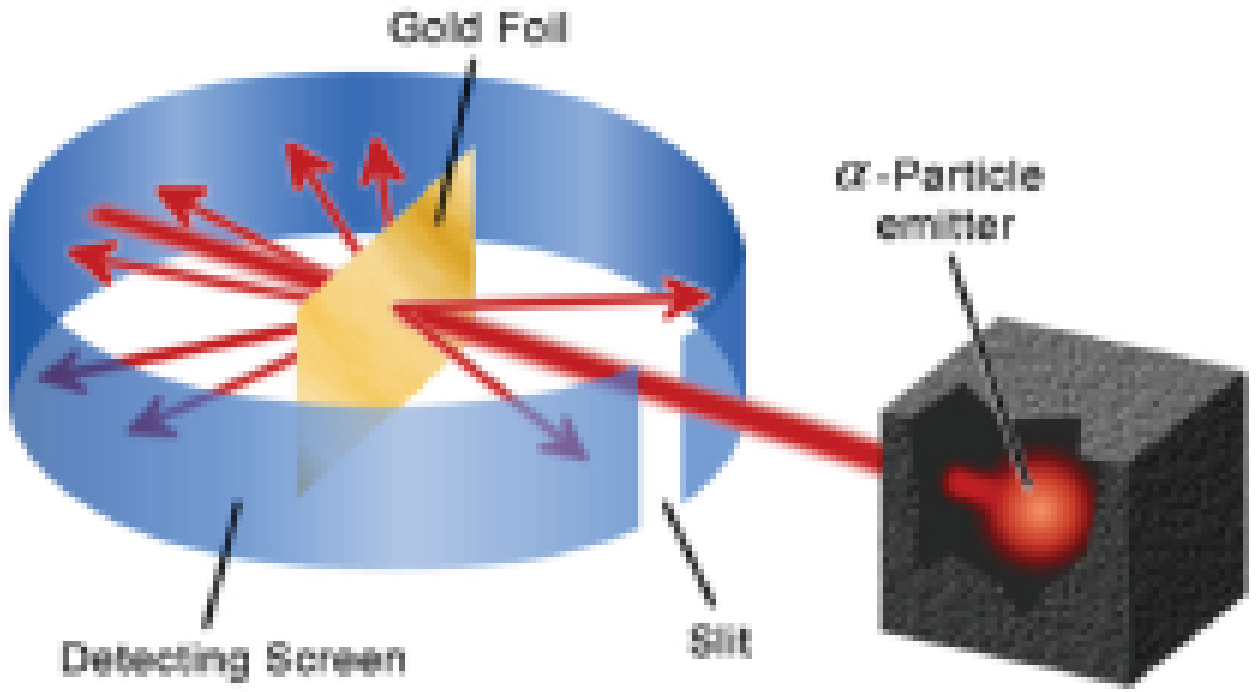
source of particles + **sheet of gold foil** + **detecting screen**

alpha particles from heating U_s in $Ra_3Br_{(g)}$

gold pounded wafer thin

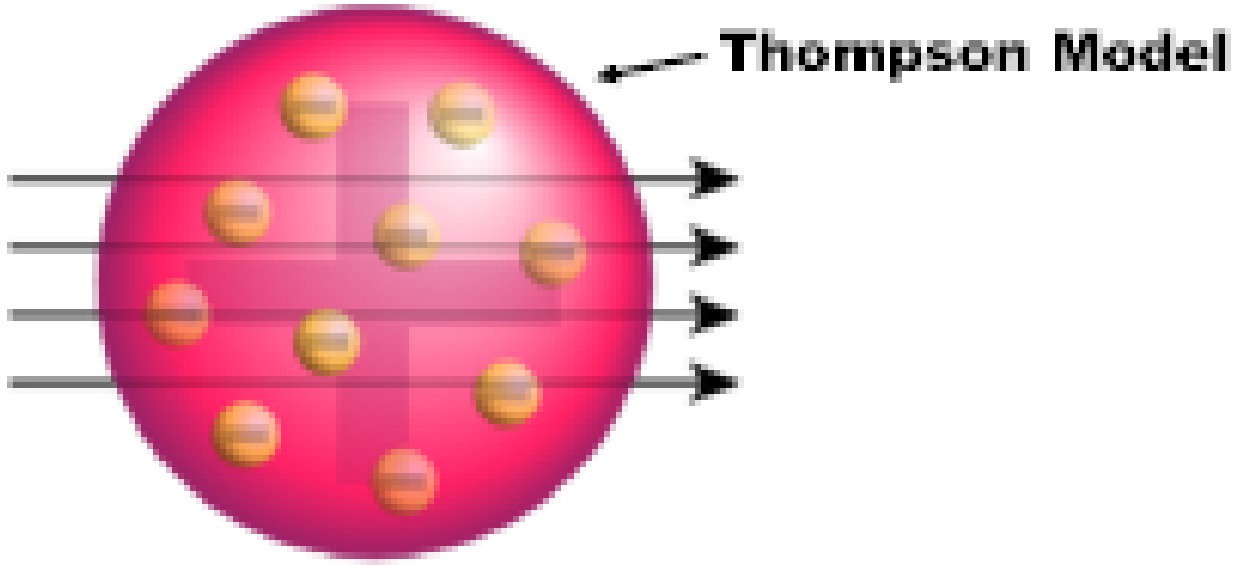
a zinc sulfide cylinder which lights up when particles hit it

The Experimental Design:



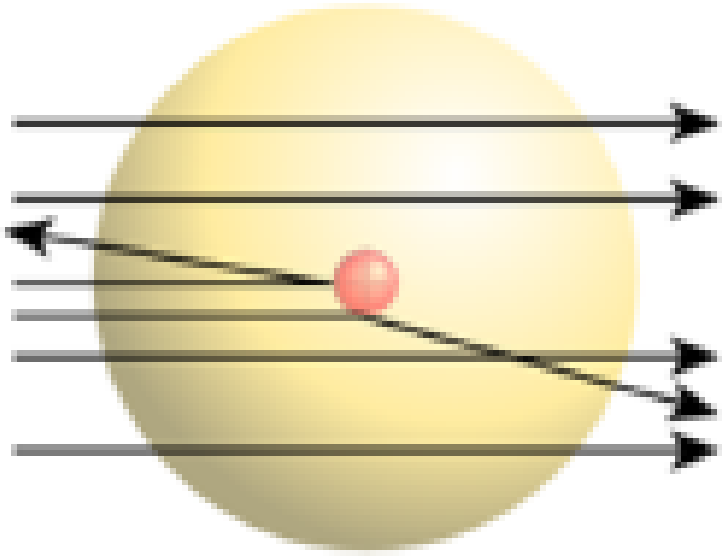
*when the particles hit the screen, a small flash or light, or a scintillation, can be seen

Hypothesis:



Rutherford aimed the beam of alpha particles at the screen. He thought that since the atom is mostly empty space, only a few particles should be deflected by the tiny electrons. Most should fly right past the foil.

Result:



However, a small number of scintillations deflected at large angles greater than 90 degrees.

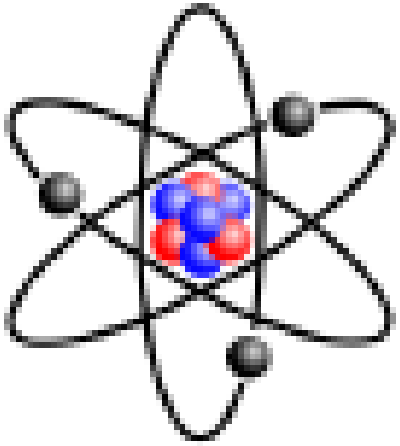
This must mean that there is something dense and large (compared to electrons) inside the atom.

That something, Rutherford decided, is the nucleus.

- "The large deflection of the alpha particle was like firing a cannon at a layer of tissue paper and having it bounce back."

Gold Foil Video

This discovery of the nucleus as a densely packed positive charge lead to a new model of the atom.



Rutherford Model of an Atom

This model has a dense positive charge in the middle (nucleus) and smaller electrons orbiting around the centre (often called the planetary model).

Successes:

- created a nucleus with positive charge and electrons outside the nucleus
- had the electrons moving in orbitals

Failures:

- electrons don't move in circles, their orbitals are closer to ellipses
- electrons are not fixed in one orbital...

Enter: Niels Bohr

- one of the most well known physicists of the 20th century

- worked with J.J. Thomson and Rutherford

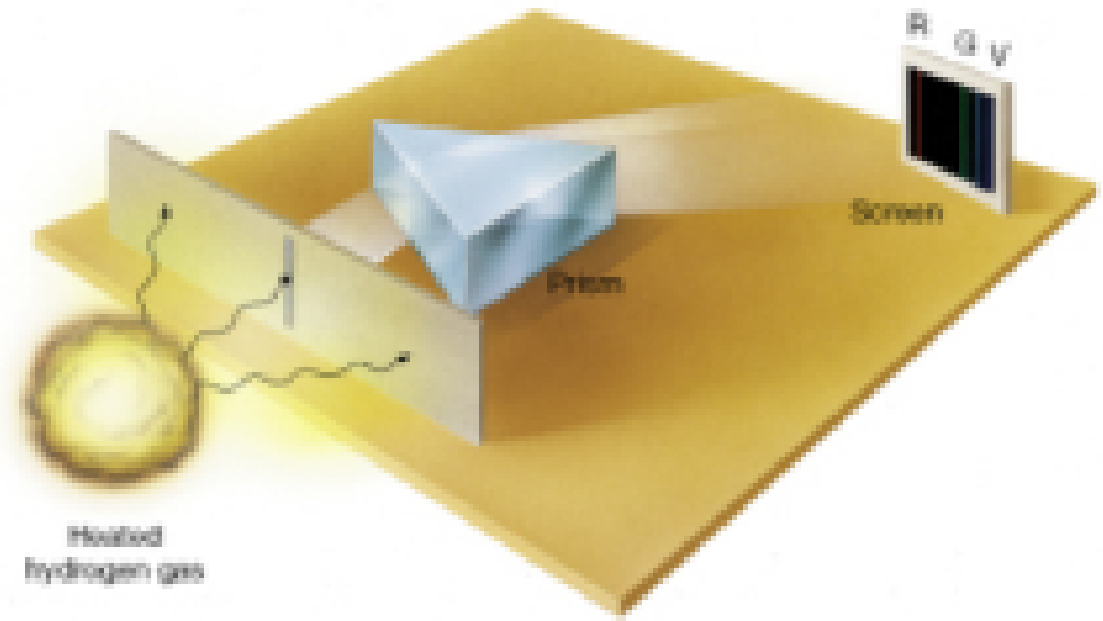
- worked on the Manhattan Project for the US government

Bohr worked with Rutherford to improve on his theory.

Bohr studied the types of light released by accelerating electrons. He did this with an emissions spectrum experiment.

In this experiment, we actually see the light produced by electrons as they accelerate.

Emission Spectrum Experiment

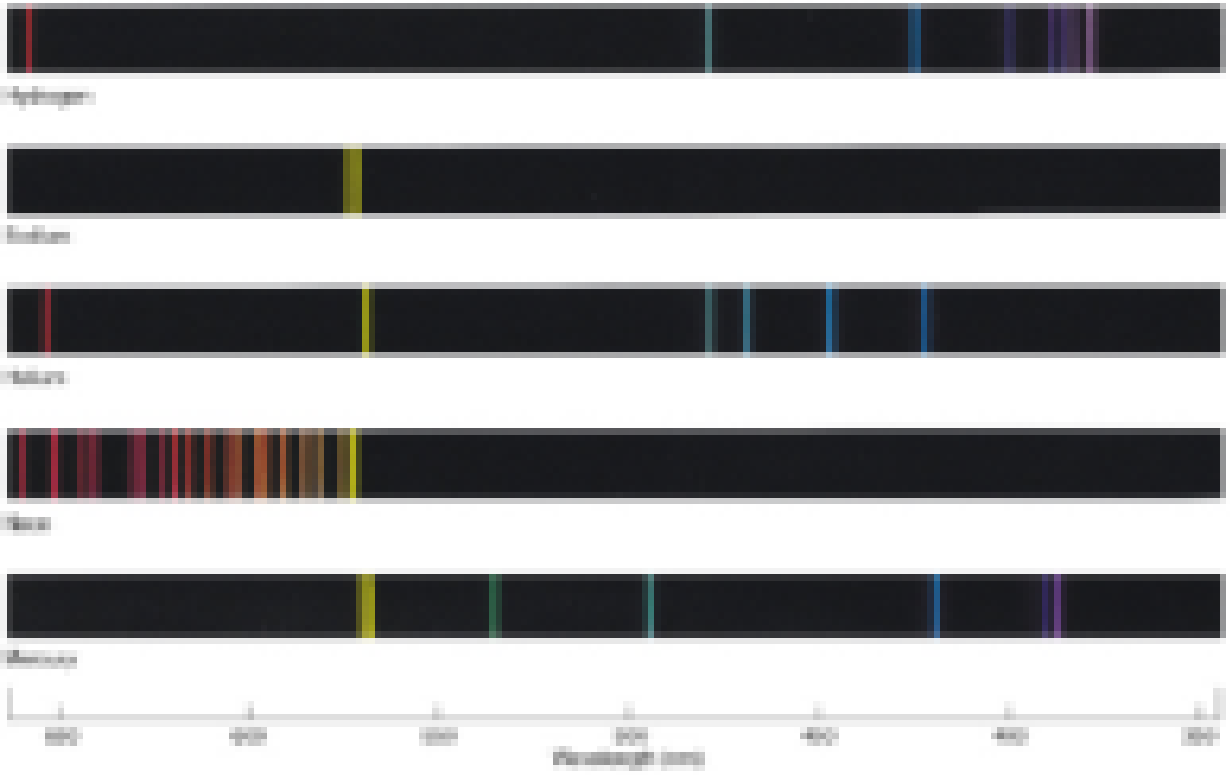


- A gas (in this case, $H_{2(g)}$) is heated. This causes electrons to accelerate and light to be produced.

- Only certain wavelengths of colour appear on the screen.

- The colours of the lines on the screen is unique for each element heated.

- Emission Spectrum



By examining the spectrums, Bohr and others later were able to identify different elements. This became known as spectroscopy.

Sucesses:

- we now have positive protons in the centre and negative electrons orbiting around the nucleus in different orbitals
- can explain colour and light from hot objects

Failures:

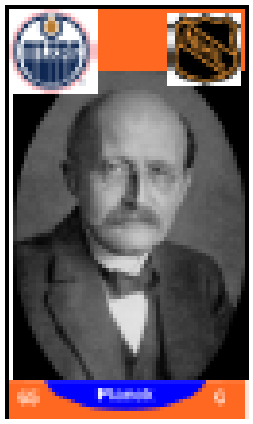
- his model only worked for hydrogen
- electrons don't actually move in set paths...

Enter: Quantum Physics

- **In the first half of the rockingest century of all (the 20th century), an All Star Team of Mr. P's favourite Physicists came up with a more precise model of the atom.**

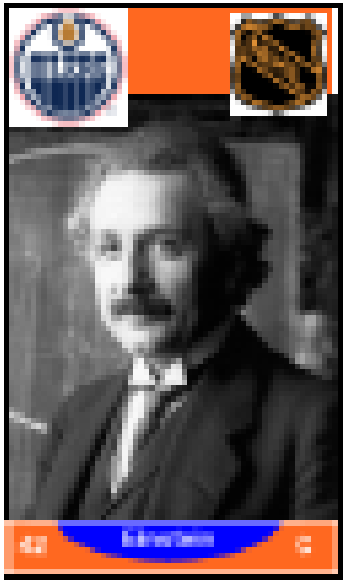
The Team Included:

Werner Heisenberg
(Heisenbery Uncertainty Theory)

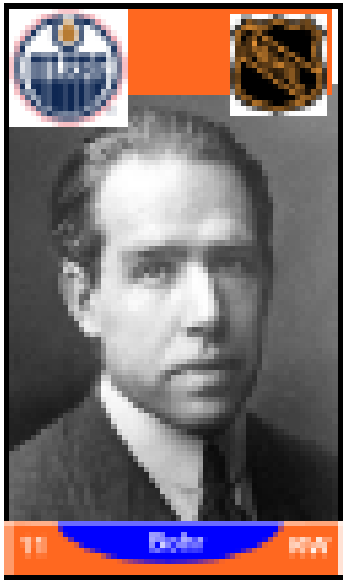


Max Planck
(Energy is quantized)

Louis de Broglie
(Matter has wave properties)

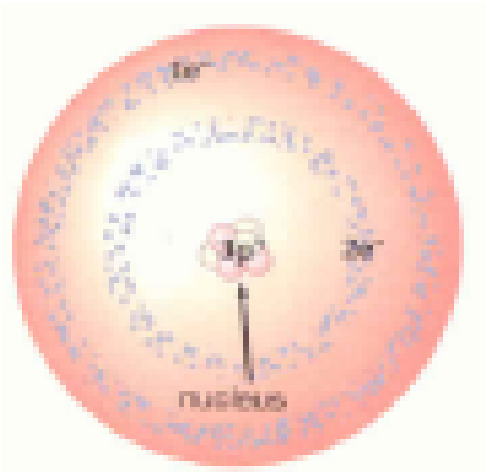


Albert Einstein
(Wave-Particle Duality)



Neils Bohr
(Electron Orbitals)

Erwin Schrodinger
(Schrodinger's Eqns)



Electron Cloud Model

Quantum theory predicts that we can not know the exact location of the electron at any given time. We can only calculate the probability of it being somewhere.

Quantum theory predicts many weird outcomes, such as:

- light behaving as both a wave and a particle
- all matter behaving like a wave
- multiple dimensions (past 4)
- that simply observing an experiment effects the outcome

However, it is quantum theory that has allowed us to device many devices we rely on today, such as:

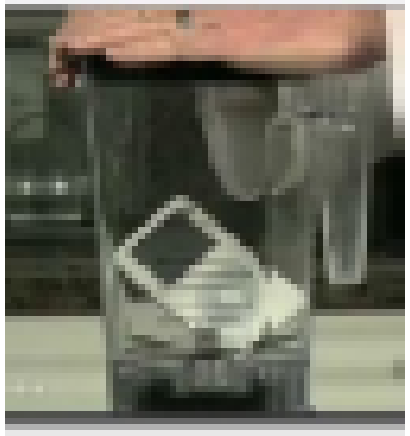
- the laser
- microchip/transistors
- electron microscope
- MRI

It has been said that 1/3 of the world's economy now relies on ideas based in quantum theory!

Classifications of Matter

Matter can be classified into two groups:

Canadian Gold Coin:
99.9999% Pure
(~$1200 CAD)

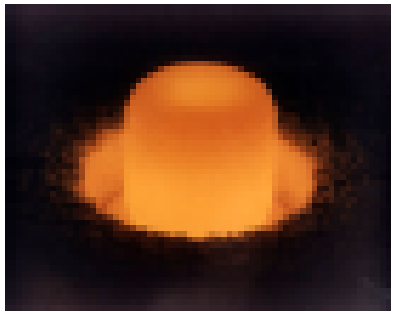


1) Pure substances

2) Mixtures

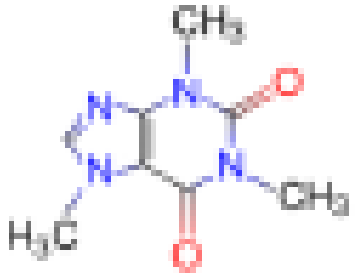
Pure Substances

- all the particles that make up the substance are identical
- e.g. elements and compounds

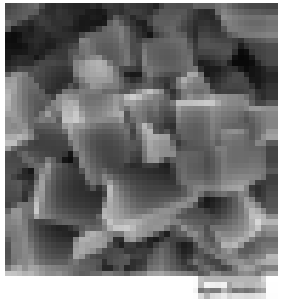


Name that Element!

Name that Element!



Name that Compound!



Name that Compound!

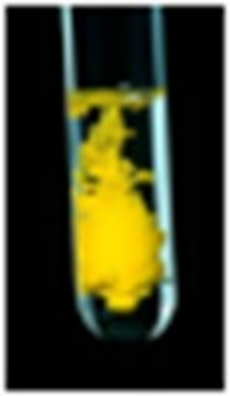
Mixtures

- combinations of pure substances
- two BIG categories of mixtures:

Homogenous Mixtures

All components of mixture look the same.

ex) solutions

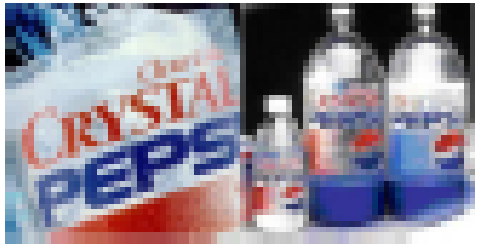


Heterogenous Mixtures

Components of mixture look different.

Examples:

Solution:



Suspension:

- different substances clearly visible but in different states

Mechanical mixture:

- different substances clearly visible

Colloid:

- different substances, can not be easily seperated